THE SPECIES OF CRICOTOPUS MIDGES LIVING IN THE BLUE-GREEN ALGA NOSTOC IN CALIFORNIA

(Diptera: Tendipedidae)

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Recently R. L. Usinger and E. M. Brock, of the University of California at Berkeley, sent me for determination a series of midges which they reared from the disclike colonies of the blue-green alga *Nostoc parmeloides* Kützing. In late summer this alga forms dense patches along several miles of Sagehen Creek[1] in the Sierra Nevada near Hobart Mills, Nevada County, California. Dr. Usinger informs me that it is almost impossible to find a colony of this alga which does not contain a midge larva or pupa in some stage of development. The purpose of this paper is to report on the identities of the midges collected and reared by Mr. Brock, who is preparing a report on the biological relationships of this seemingly obligate association.

The material received for determination consisted of large larvae and pupae taken on 15 August, 1953 and 30 July, 1954, and of male and female adults of two new species of *Cricotopus* reared from the alga in August and September, 1954. Although adults of the two species do not have the prominent white-banded legs, pale-banded abdomen, or whitish genitalia characteristic of *Cricotopus* in the strict sense, the presence of dense pubescence on the eyes, absence of macrotrichia on the wing, absence of distinct erect hairs arising from obvious punctures on the mesonotum, and presence of a complete fringe of hairs on the squama place both species in *Cricotopus,* Group C of Edwards (1929), with species formerly referred by various authors to *Trichocladius* Kieffer.

The larvae of some species of *Cricotopus,* including *exilis* Johannsen and *fugax* (Johannsen), live in silken tubes on the rocky bottoms of shallow, swift-flowing streams (Johannsen, 1937). Those of a second group of species, including *trifasciatus* (Panzer) and *sylvestris* (Fabricius), live in silken tubes within feeding channels which they make through one epidermal layer and into the mesophyll of various aquatic plants. Species of this

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group are important pests of rice wherever it is grown (Risbec, 1951). Larvae of a third group of species including *brevipalpis* Kieffer, *elegans* Johannsen, and *flavipes* Johannsen, are true leaf miners between the epidermal layers of aquatic plants such as water lilies and *Potamogeton* (Berg, 1950). Larvae of the first and second groups have long antennae, while those of the second and third groups have a pair of long hair tufts on the sides of each abdominal segment. The *Nostoc*-dwelling larvae belong to a fourth group, apparently not previously recognized, having short antennae and no hair tufts.

Berg *(loc. cit.)*, in his excellent account of the biology of *C. flavipes,* which mines in several species of *Potamogeton* in Michigan, reported that he was unable to find small larvae of this species in the leaf mines, but discovered what he reasonably assumed, on the basis of morphological similarities, to be younger larvae of the species living in longitudinal excavations in *Potamogeton* stems. The following quotation from Berg shows how the leaf-mining habit may have been developed from alga-feeding species and also how the combined needs of food and shelter may be satisfied in different ways in related species or during various stages of a single species:

> "Besides providing evidence concerning the mode of hibernation of *C. flavipes* and the form and habitat of its younger larvae, the discovery mentioned supplies indications that these young larvae may utilize a type of food which is quite unusual among mining insects. Each mine that was opened contained quantities of algae which were identified by Wm. Randolph Taylor as Nostoc, Anabaena, Tolypothrix, Oscillatoria, Schizothrix, and Rhopalodia. These algae appeared to be alive and in good condition. Since each mine opened to the exterior by at least one hole through the epidermis, it is possible that the larvae brought small pieces of living filaments into the mines, and that the algae were growing as rapidly as they were being eaten. Unfortunately, no recognizable material was found in the stomachs of freshly killed larvae."

Cricotopus nostocicola Wirth, new species

(Figures 1, 2)

Length 4.3 mm. by 0.7 mm.

Male. Color entirely black, membranous portions of body including halteres brownish black; wings somewhat milky, veins blackish; antennal plume black. Last antennal segment 1.3 times as long as preceding 12 segments combined. Palpal segments with lengths in proportion of 20:30:30:40. Legs, except on fore tibia and tarsus, with abundant long hairs, length of hairs up to 2-3 times diameter of segments. Fore leg with segments from femur distad in proportion of 90:110:64:38;28:20:15; fore basitarsus thus

0.58 times as long as tibia. Both claws on each leg pectinate at apex; empodium minute. Wing with costa very slightly produced beyond end of R4-5; mediocubitus forking distinctly beyond r-m crossvein. Scutellum with long hairs. Abdominal segments with abundant, long, black hairs arising from coarse punctures. Genitalia as figured (fig. 1a), a small but distinct anal point present; basistyle with a large mesal lobe which is bare dorsally but finely setose ventrally; dististyle stout, blunt apically.

Female. As in the male with usual sexual differences. Color dark brown where the male is black, but pronotum, mesonotum, except for the usual three broad, dark brown vittae, pleura, except for two dark spots, cerci and most of abdominal venter obscurely yellowish. Hairs on legs and abdomen shorter than in male. Antennal flagellum six-segmented (proportions 16:10: 13:14:16:40). Spermathecae two, pyriform, each with heavily sclerotized neck arising at postero-ventral end (fig. 1c). Fifth, sixth and seventh sternites each with a mesal patch of moderately long, appressed, black hairs. Cerci (fig 1b) with central ends bluntly rounded.

Holotype male, SAGEHEN CREEK NEAR HOBART MILLS, NEVADA COUNTY, CALIFORNIA, 2 September, 1954, E. M. Brock (type No. 62838, U.S.N.M.). Allotype, five male and two female paratypes, same data except dates 25 August to 2 September, 1954. Paratypes are deposited in the collections of the Academy of Natural Sciences of Philadelphia, the California Academy of Sciences at San Francisco, and Cornell University at Ithaca, New York.

The entirely dark legs and abdomen will separate *nostocicola* from all described Nearctic species of *Cricotopus* except *oceanicus* (Packard), *infuscatus* (Malloch) and *fuscatus* (Wirth) from which it differs in its dark halters and the uniformly black color of the male.

The following descriptions of the immature stages of *nostocicola* are made from a vial of preserved colonies of *Nostoc* in the U.S. National Museum collection from Pine Creek, Spirit Lake Ranger District, Columbia National Forest, Oregon, 24 February, 1938, A. Roth, collector. Each colony contained a single large larva or pupa of *Cricotopus,* and by boiling gently in dilute caustic the larva or pupa inside could be relaxed and restored for identification. Several colonies contained pupae mature enough that the species could be recognized by male and female genitalic characters. The last larval skin was always to be found inside the colony close by the pupa, thus enabling one definitely to associate larval, pupal and adult characters of this species.

Pupa. Length about 7 mm. Prothoracic repiratory organs lacking. Second abdominal tergite with a very narrow, transverse band of fine shagreen on posterior margin. Laterposterior corners of ninth tergite produced caudodorsad in a pair of curved, black-tipped, conical lobes with armature of numerous, small, blunt, dorsally directed, black spines. All other known species of *Cricotopus* pupae possess prothoracic respiratory organs and none has this peculiar armature of the ninth tergite.

Larva. Length about 8 mm. when mature. Head nearly black, body yellowish-white; thorax slightly violet-tinted in large larvae. Hair tufts on sides of body segments lacking. Four slightly tapering anal gills present, each nearly as long at its base as diameter of segment. Preanal dorsal papillae short, each bearing about six bristles about as long as posterior prolegs.

Head greatly down-curved and tapered anteriorly, its dorsal length in profile about twice its length on ventral midline; with two eyespots, the ventral one slightly anterior to, and much smaller than, the dorsal one on each side. Antenna (fig. 3b) very short, first segment 1.2 to 1.6 times as long as broad, with sensory pore beyond middle to slightly proximad of middle of segment. First antennal segment with the longer, hyaline blade at apex greatly exceeding tip of fifth segment, the second blade minute. Torma, or "premandible" (fig. 3c) stout, with two broad, rounded anterodistal lobes. Mandible (fig. 3d) very stout, with several deeply marked wrinkles on dorsal convex side and a long mesal brush arising near base. Hypostomal or "labial" plate (fig. 3a) strongly convex transversely, with a broad, toothless mesal portion much elongated, flanked on each side by six or seven small lateral teeth.

Cricotopus fuscatus Wirth, new species

(Figure 2)

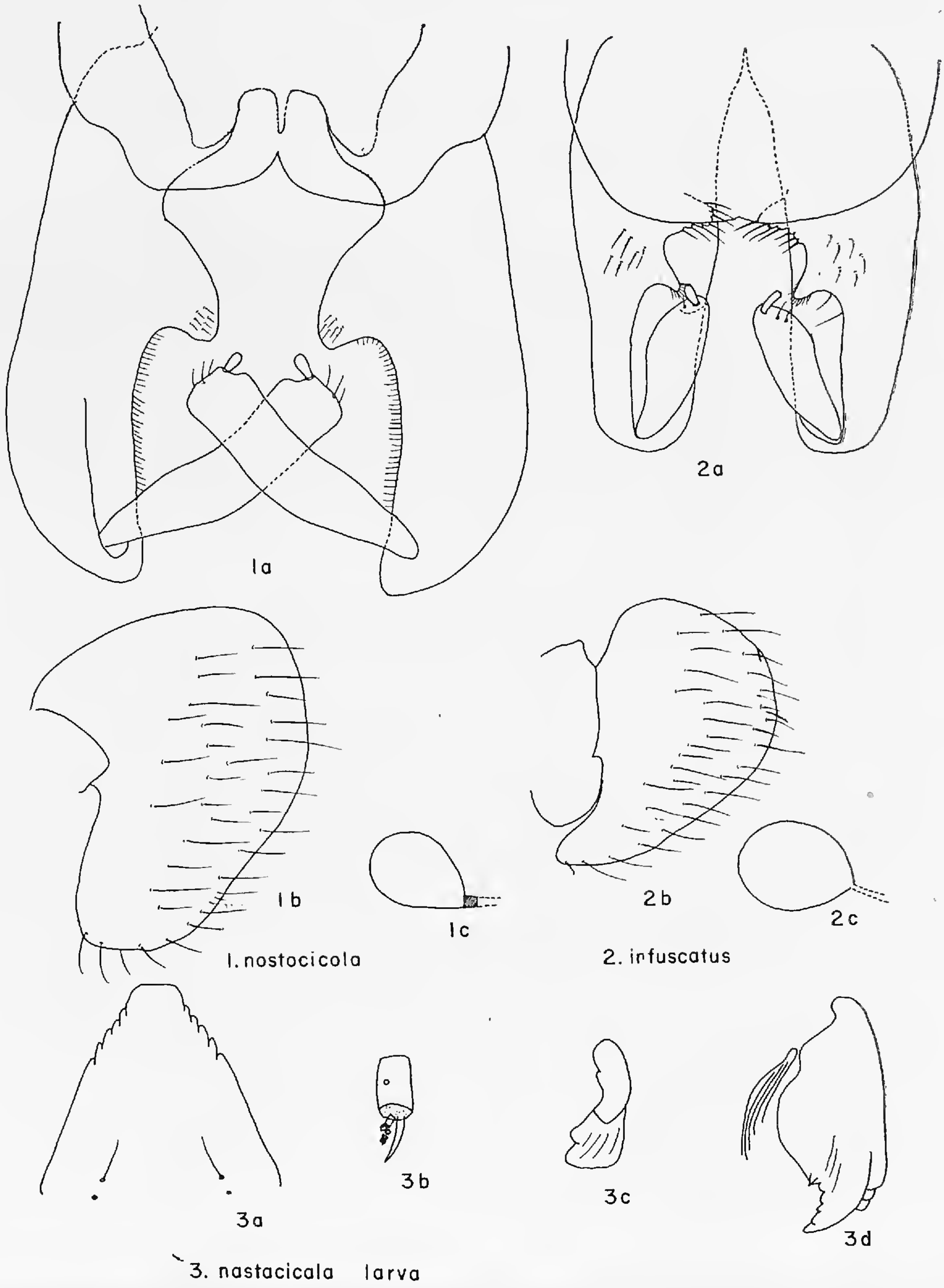
Mr. Brock also reared a second new species of *Cricotopus* from *Nostoc* colonies. Adults of this species closely resemble those of *nostocicola* in structure, but can be readily distinguished by the following characters:

Color paler, both males and females with body bright yellow, the three mesonotal vittae reddish brown, a small black spot at the posterior end of each lateral vitta just in front of scutellum; postscutellum black except narrowly yellow at base; flagellum of antenna, palpus, legs, except coxae, trochanters and proximal half of middle femur, dorsum of abdomen and eighth and ninth sternites of female, dark brown; wings grayish in transmitted light, milky by reflected light; halteres yellowish. Female abdomen with prominent median tufts of long pale hairs on sternites 6 and 7; cerci (fig. 2b) with ventral ends quite narrowly tapered; spermathecae (fig. 2c) oval, the bases of the ducts without sclerotized necks. Male genitalia (fig. 2a) with two small setose lobes on each basistyle.

Holotype male, SAGEHEN CREEK NEAR HOBART MILLS, NEVADA COUNTY, CALIFORNIA, 31 August, 1954, E. M. Brock (type No. 62857, U.S.N.M.). Allotype female, 11 male and 10 female paratypes, same data as type. Paratypes are deposited in the collections of the Academy of Natural Sciences of Philadelphia, the California

Academy of Sciences at San Francisco, the Cornell University at Ithaca, New York and Illinois Natural History Survey at Urbana.

This species is very closely related to *infuscatus* (Malloch) from Illinois which also has the two setose lobes on the male basistyle. Malloch's species, however, has the mesonotal vittae



Explanation of Figures

Fig. 1. *Cricotopus nostocicola.* Fig. 2. *C. fuscatus,* a, male genitalia; b, female cercus; c. female spermatheca. Fig. 3. *C. nostocicola,* larva, a, hypostomal plate; b. antenna; c. torma; d, mandible.

glossy black and the legs with more extensive pale markings, with the fore coxa, trochanter, the bases of all femora, the mid and hind tibiae and bases of their tarsi, greenish yellow. I am greatly indebted to Dr. Selwyn S. Roback of the Academy of Natural Sciences of Philadelphia for pointing out the specific nature of these differences in color.

The 15 August, 1953, collection from Sagehen Creek consisted of one female pupa of *nostocicola* and one female pupa of *fuscatus* both of which after clearing in phenol could be identified by the internal genitalic characters of the developing imago, as well as three larvae which could not be determined to species. The 30 July, 1954, collection consisted of one male and four female pupae of *nostocicola*, two female pupae of *fuscatus* and two male and two female pupae too immature for genitalic characters, as well as 26 larvae which could not be specifically determined. Known pupae of *nostocicola* and *fuscatus* could not be separated specifically, and no doubt the larvae of both species were present although no characters were found to separate any of them.

The larvae of *nostocicola* and *fuscatus* are indistinguishable from those which Johannsen (1937, p. 75) described and figured as "*Spaniotoma* sp. G." Henry Dietrich of Cornell University kindly made available to me two of Johannsen's larvae slides from Cos Cob, Connecticut, and also one larva on a slide collected from *Nostoc* in the Callowash River, Oregon, by P. R. Needham, all determined as "*Spaniotoma* sp. G" by Johannsen and agreeing with the larva of *nostocicola*.

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